THE GASES PRESENT IN THE FLOATS (VESICLES) OF CERTAIN MARINE ALGÆ.

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Amongst our Australian Marine Algæ, vesicles filled with gas are found only in a few genera of the Brown Seaweeds, Fucoideæ. These are *Sargassum*, *Carpophyllum*, *Turbinaria*, *Cystophora*, *Cystoseira* (more typically a Northern genus), *Scaberia*, *Phyllospora* amongst the Sargassaceæ; *Hormosira* of the Fucaceæ; *Macrocystis*, and possibly *Adenocystis*, of the Laminariaceæ. Several receive their names from the habit.

The function of the vesicles is evidently to support the fronds in a more or less upright position in the water. In young plants, and, in sheltered situations in shallow water, in even the mature fruit-bearing individuals, there are no vesicles. This often causes difficulty in the identification of a form which normally bears characteristic vesicles.

I have not seen anywhere any account of analyses of the gases occurring in the floats of seaweeds, and have accordingly devoted some little time to this inquiry as to the nature of the gaseous content. Naturally the question of the origin of the gases is most prominent in one's mind. There seem to be three possible sources: (1) atmospheric air, (2) the gases dissolved in sea-water, (3) gases produced in the metabolism of the plants themselves. The main object of my experiments was to see if the results would decide which of the three is the actual source.

I may say, at once, that I have never detected any gases beyond nitrogen and oxygen in the floats. It is hardly conceivable that any process of metabolism should yield these two gases only, without any carbon compounds. The issue is then narrowed, and the gases must be derived from those of the atmosphere, or those dissolved in the sea-water.

I tried other methods of analysis, but found that absorption by phosphorus over water was the cleanest, surest, and readiest. Practically in a couple of hours, fresh cut phosphorus removed all the oxygen which my simple apparatus could measure. By choosing the time of the day for the experiments, the total volume and the volume of the remaining nitrogen could be determined under practically the same conditions of temperature and pressure. I do not claim any extreme accuracy for the experiments.

First, by way of testing the method, I made several analyses of atmospheric air, of air dissolved in tap-water, and of the gases dissolved in sea-water. The ratio of nitrogen to oxygen given by the apparatus for air, was the orthodox 79 : 21. To collect the gas from water, the water was boiled into a vessel containing water made previously gas-free by prolonged boiling. Thus 250 c.c. of tap-water yielded 3·9 c.c. at ordinary temperature and pressure, of which 2·6 c.c. were nitrogen, and 1·3 c.c. oxygen. The ratio of the nitrogen to the oxygen was then 2 : 1, as it should be if all the gas were dissolved from atmospheric air, inasmuch as oxygen is twice as soluble as nitrogen. There was no carbon dioxide.

The analyses of sea-water gas varied considerably, as might be expected. On referring to the analyses of South Pacific Surface Water collected by the "Challenger," I found that of 16 analyses published in the Report, no two were alike. The carbon dioxide varied from 10·18 to 23·12 per cent. of the total gas. The ratio of nitrogen to oxygen varied from 62·43 : 26·59 to 54·51 : 28·64, evidently varying about a mean of 2 : 1. It would seem that the presence of organisms alters considerably the natural ratio of the gases dissolved from the air. One of the analyses I obtained was—

In 100 vols. of sea-water gas

Nitrogen	67·12
Oxygen	26·03
CO_2	6·85
	100·00

The water was wave-water taken off the shore at Bondi, on the ocean beach. 250 c.c. of sea-water yielded 3·65 c.c. of gas, or at the rate of 14·6 c.c. per litre. The "Challenger" average was 15 c.c.

Another analysis of Coogee ocean-water gave –

In 100 vols. of sea-water gas

Nitrogen	58·33
Oxygen	30·55
CO_2	11·11
	99·99

This is almost identical with a "Challenger" analysis.

The following is a Table of the analyses of the gases of the floats of some of our algæ.

Species.	Percentage of Nitrogen.	Percentage of Oxygen.	Comments.
Phyllospora comosa (1)	86·0	14·0	Fresh-looking plants cast up on the shore.
,, ,, (2)	89·4	10·6	Just cast up.
,, ,, (3)	88·9	11·1	,,
,, ,, (4)	82·3	17·7	,,
,, ,, (5)	83·2	16·8	,,
Hormosira banksii (1)	88·46	11·54	Growing.
,, ,, (2)	88·0	12·0	Same gathering kept a day longer.
Cystophora monilifera	80·0	20·0	Floating in the sea.

The analyses disappointed me, for I, perhaps unreasonably, hoped for nearly uniform results. With the exception of the last, however, it will be seen that in all the proportion of oxygen is less, usually much less, than if air had been taken directly into the cavity, and in all the proportion is notably less than in air dissolved in water.

The proportion of oxygen being then less than in ordinary air, and much less than in water-dissolved air, it would seem that the plants, however they may obtain the gas, use up some of the oxygen, sometimes a good deal, for other purposes than levitation.

The analyses give no decisive evidence as to which of the two possible sources of supply is the actual one. The gases as found may be residues of either ordinary or water-dissolved air. The plants, while in the main submerged, are at low water as large waves retire, exposed to the air. *Hormosira* may often be left quite exposed at low tide. The vesicle is always closed; there are no passages or pores in the walls. The structure of the walls is as continuous as that of the rest of the frond. The vesicle originates in a solid growth from the frond, the growing cells gradually separating from the centre and leaving a central cavity. Hence diffusion from the air seems to be excluded, for the gas must be formed in the cavity, *pari passu*, with its growth, otherwise the vesicle would collapse. Hence we seem to be driven to osmosis, or osmosis with selective absorption, as the process by which the gas passes, dissolved in water, through the cells of the plant until the residue is set free in the cavity. Algæ obtain all their nourishment, including the oxygen necessary for respiration, from the surrounding sea-water, and there must exist a circulation from cell to cell, which I have termed, perhaps rather crudely, a selective osmosis. It is in this way that the plants obtain their salts, with a marked preference for potassium sulphate, and their oxygen, and it seems perfectly natural that just as common salt is very generally rejected, not absorbed, so the useless nitrogen, together with the oxygen not required, may be eliminated, and set free in the floats in order to serve a mechanical purpose. All the surface of the plant can be employed in the initial absorption, and in many individuals the great number of the floats seems to require some such general agency. I consider, then, that the source of the gases is the gas dissolved in the surrounding sea-water.

The Gases of the Inflated Capsules of two Land-plants.

It was suggested to me by Mr. T. Steel, that I should examine, as a parallel investigation, the gaseous contents of the Balloon Vine, *Cardiospermum Halicacabum* L., plants of which were growing in his garden. He kindly supplied me with sufficient of the balloons, freshly gathered from the vine. A single balloon yielded over 10 c.c. of gas.

No evidence could be obtained of the presence of carbon dioxide above the amount ordinarily present in air. There was no evident absorption by potash; and though the gas was allowed to stand over lime-water for six hours, not the slightest film of carbonate formed on the surface.

Three separate determinations of oxygen were made by the phosphorus method. Simultaneously with the third sample of gas, an equal volume (10 c.c.) of air was tested under practically the same conditions of temperature and pressure The results were—

Gas No. 1.	Oxygen 20·3 %.	Using graduated	vessel		A.
Gas No. 2.	Oxygen 19·0 %.	,,	,,	,,	B.
Gas No. 3.	Oxygen 20·0 %.	,,	,,	,,	A.
Air.	Oxygen 19·0 %.	,,	,,	,,	B.

It seems plain, then, that the gas is identical with ordinary air, the difference in reading being probably due to the slightly unequal graduations of the two measuring vessels.

The balloons were of a vivid tender green The outer surface has a distinct epidermis provided with hairs and stomata. There is no inner epidermis, the lining tissue having the same loose structure as that of the septa dividing the capsule. It is plain, then, that atmospheric air can be admitted under the control of the guard-cells of the stomata, and can penetrate all the loose tissues of the thin capsule-walls, passing through to the cavity within. As the balloons were gathered in the early morning, it would seem that any free carbon dioxide formed during respiration passes out of the stomata, and does not accumulate inside the capsule.

The use of the balloons is apparently to allow of the distribution of the capsules by the wind. They are easily detached when ripe, and from their shape can be rolled along the ground as well as carried in the air. And the plant secures the gas necessary for inflation by the readiest means from the handiest supply. *i.e.*, the surrounding atmosphere.

While staying at the entrance to the Tuggerah Lakes, I gathered the inflated capsules of the Wild Cotton Plant, *Gomphocarpus fruticosus* R. Br., and made parallel analyses of the contained gas, and of the air of the place. In the former I found 21 % of oxygen, and in the latter 21·1 %. This also shows that the cavities were filled with air drawn directly from the atmosphere.

Portuguese Man of War.

At the same place, I found a number of Portuguese Men of War freshly thrown up on the ocean beach, and tested the gas of the floats in the same way. It appeared to be identical with the atmospheric air analysed at the same time. Here diffusion seems to be the process by which the float is filled, the growth of the cells providing the necessary cavity. The membrane appears to be thin enough for diffusion to be able to act.